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14. ABSTRACT

This report documents research performed under the contract entitled,"A Virtual Environment for Visualization and Computational Technologies Enabling Autonomous Vehicles". This experimental facility is essentially a real-time virtual image generation system comprised of two major components- a computational rendering engine and a database. Collectively, these two components form a unique closed-loop test facility for studying vision-based control of autonomous flight vehicles. The most important milestone achieved last year was the design and construction of the new visualization laboratory. This laboratory is equipped to display virtual environments for MAV flight simulations. Currently, a University of Florida campus database, developed by the UF DigitalWorlds Institute, is being used as the virtual environment for studying vision-based control of MAVs in urban environments. This report provides a description of the new visualization laboratory and the virtual UF campus database. Additionally, the project has developed capabilities for the REEF that will enable greater interaction between the Air Force, and particularly Eglin Air Force Base, and its research partners. The REEF will serve as a hub for collaboration between academia and industry to the Air Force. The visualization laboratory is a major component to enable these collaborations.

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A Virtual Environment for Visualization and Computational Technologies Enabling Autonomous Vehicles

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1 Introduction

This report documents research performed under the contract entitled "A Virtual Environment for Visualization and Computational Technologies Enabling Autonomous Vehicles." This experimental facility is essentially a real-time virtual image generation system comprised of two major components - a computational rendering engine and a database. Collectively, these two components form a unique closed-loop test facility for studying vision-based control of autonomous flight vehicles.

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2 Year 1 Progress

2.1 Visualization Laboratory

The visualization facility consists of a virtual environment displayed on a set of flat-screen monitor screens. The UF Digital Worlds Institute, headed by Dr. James Oliverio and Dr. Andy Quay, designed and built most of the hardware system for the virtual environment. The virtual environment software is built upon MultiGen-Paradigm's distributed VEGA, which enables the loading of urban databases and synchronizes the video screens driven by a PC image cluster. The display system is depicted in Figure (1). Note these screens can easily be configured in different fashions to separate the screens as desired.

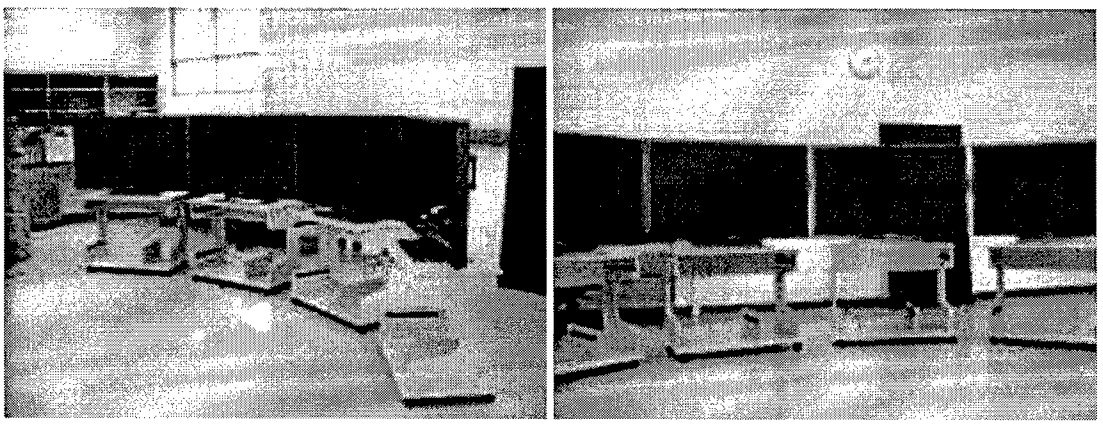

Figure 1: The Display System in the Visualization Laboratory.

The laboratory is established in room 169 of the REEF. That location provides a room size of $48x30x17\ ft$ which is ample space for its needs. The room contains necessary power and lighting along with air conditioning to accomodate the computational hardware. Additionally, the room is located adjacent to the aerodynamic characterization laboratory which will house a wind tunnel and, eventually, be used for closed-loop hardware-in-the-loop simulations (HILS) of flight. The location of the laboratories within the REEF are shown in Figure 2.

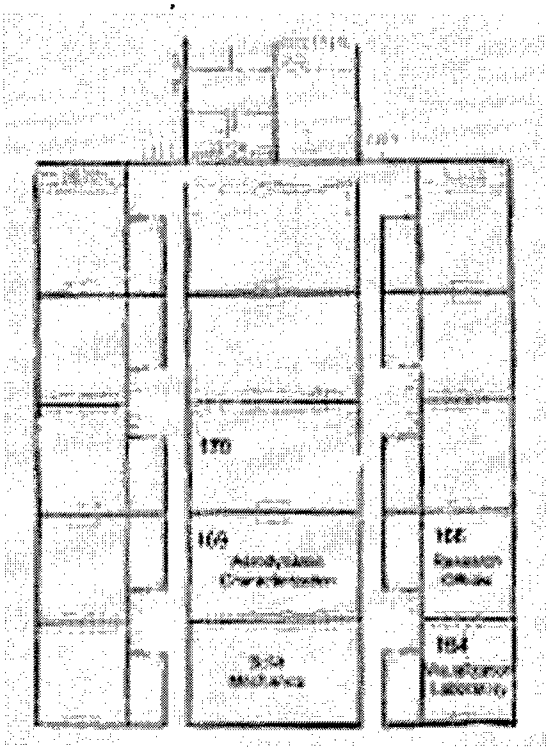

Figure 2: Laboratories within REEF

The following items were purchased in constructing the visualization laboratory:

- 10 Dell Optiplex computers (3 GHz processor)
- 11 Dell Precision workstations
- 13 NVidia Quadro FX 3000 video cards
- MultiGen Paradigm 3 year educational site license
- Multimedia (DVD and VCR)
- 1 Digital Camera
- Video Switcher
- 4 Panasonic 50 *in* Plasma Displays

- Projection system
- Miscellaneous cabling and adapters
- Laboratory infrastructure: cabinets, carpeting, etc.

Finally, the software architecture of the visualization facility is depicted in Figure (3). The inter-relationships of the various elements associated with displaying a virtual environment are shown in the figure. Basically, an urban database is stored and rendered according to the position of the MAV in the virtual environment. This is accomplished using the MultiGen software which also incorporates any special effects such as reflections and shadowing. The distributed rendering utilities ensure that the three displays are synchronized since individual views are typically rendered at different rates.

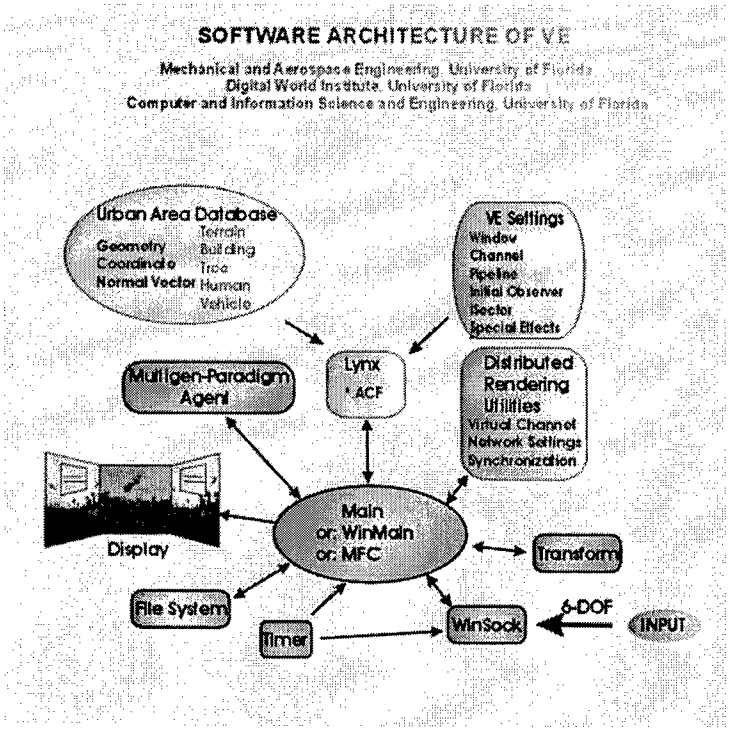

Figure 3: Software architecture of the visualization facility.

2.2 Virtual Environment Database

2.2.1 University of Florida Campus

The visualization laboratory currently displays a UF campus database that was developed by the Digital Worlds Institute. This database contains high-resolution imagery of the exteriors of most of the buildings on the UF campus and will serve as the main virtual environment for testing vision-based control algorithms for MAVs. Also, the database has been updated to provide more exterior details as well as views of some building interiors. The UF campus database, displayed in the Research, Education and Visualization Environment (REVE) at the Digital Worlds Institute, is shown on the right in Figure (4).

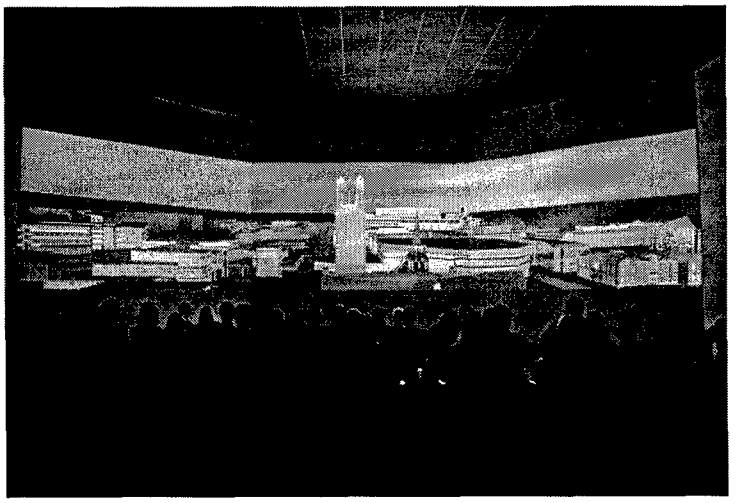

Figure 4: UF campus database displayed in the REVE at the UF Digital Worlds Institute.

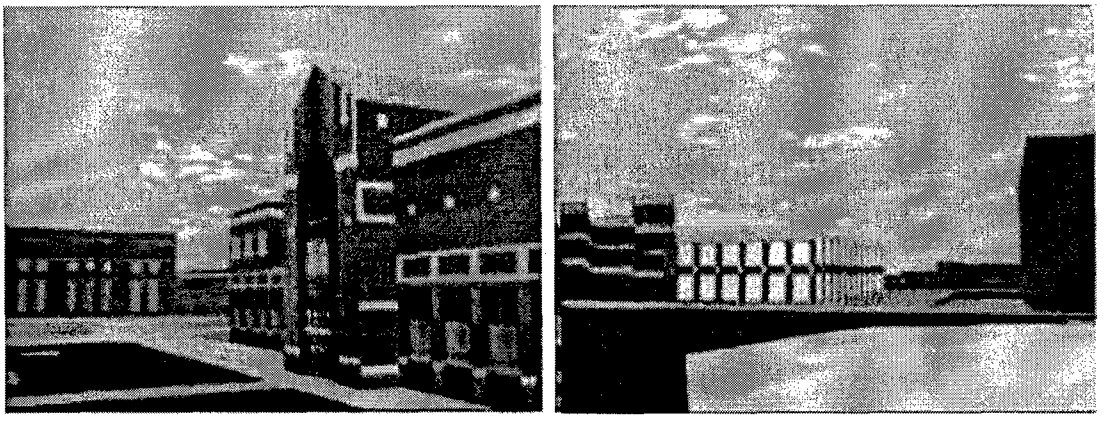

Figure 5: Virtual images from a simulated MAV flight through the UF campus database.

It should be noted that the visualization facility currently has the ability to display multiple camera views. These can be continuous views such that the multiple-screen display shows one panoramic image, as illustrated in Figures (1) and (4). Alternatively, they can be completely separate views as might be seen from different MAVs in the environment. Figure (5) illustrates two virtual images from a single camera view during a simulated MAV flight through the campus database.

2.2.2 Fort Benning

A database of similar quality and resolution is being constructed to model the urban testrange at Fort Benning, GA. A contract was awarded to Quantum 3D Corporation, as suggested by Eglin Air Force Base, to produce the desired database. Researchers from the company and the University of Florida have had extensive communication on this issue and even traveled together to Fort Benning to walk through the site. The complexity of the database is extremely high so the entire model has not been generated yet but will be available within 3 months of this report.

2.3 Access Grid

An access grid is installed at both the REEF and the Gainesville campus of the University of Florida. This access grid is essentially a high-bandwidth high-resolution system for video conferencing. Each system includes 4 video cameras to capture multiple views of multiple people attending the conference. The resulting images can be displayed on the screens already used by the visualization laboratories at each location. Also, the system is directly linked to the computers such that presentations and files can be directly shared during the video conference.